ENFORCEMENT SENSITIVE

Dup 8b → 1e WA2917 2/23/94

DRAFT

February 23, 1994

TO:MR. DAVID CROXTON
HW-106

RECEIVED MAR 2 3 1994 RCRA PERMITS SECTION

FROM:ROBERT FARRELL

SUBJECT:BURLINGTON, PIER 91, OCTOBER, 1993 RFI REVIEW

FILE COPY

Summary--The investigation into the shallower aquifer seems to be adequately done so that a corrective action program can be developed. The RFI for the deeper ground water does not appear to have been adequately completed and numerous questions still remain to be answered.

GEOLOGY

The overall stratigraphy as described in the RFI indicates a paved or cement surface layer almost everywhere. Below this is a 15 to 20 foot thick sand layer that BEI considers to be fill. Below this fill sand is a silty sand, sandy silt, and/or silt layer that is considered by BEI to be of such low K that it is an aquitard. Below this is another sand layer forming a wedge that thickens from the north end of the site (105) where it is not present to over 20 feet thick at the southern end of the site (108). Below this lower sand wedge BEI defines another silty layer of unknown thickness.

This simple stratigraphy is not in total agreement with either BEI's boring logs nor with boring logs from investigations that have occurred adjacent to BEI's property. The MW-39 wells installed just west of the site did not encounter the silty sand layer at all. The borings and cross sections done for building W-390 indicate that the silty layer starts at depths below the ground surface of 5 to 6 feet in four of the five borings. This elevation is about 10 feet above the silty sand layer encountered in BEI's borings at 112, 104, and 113 (the elevation for the silty layers from these off site borings have been estimated using a ground surface elevation of 5 to 6 feet). Within the BEI facility borings 107, 109, 112, 115A, 116, 117, 118, and 119 encountered a silt layer at approximately the depth of 5 to 6 feet below the ground surface. Other borings, W-10, 39-2, 114, TB2, TB7, SB1, and SB2 also indicated a silt layer about 10 feet higher than the surface of the silty sand defined by BEI. The building 390 investigation considered this layer, at a depth of 5 to 6 feet, to be the original surface of the cove that was filled. Such an interpretation of the data indicates that the sediments below an elevation of about 1 to -1 would be pre-fill and natural in origin. The silt layer appears to have holes in it, and, where it is not present, it is difficult to distinguish the natural sand from the fill sand.

Δ RFI Report accordingly

Figure 4-4 presents BEI's interpretation of the shape of the top of the sandy silt layer. Within the text this layer is normally referred to as a silty sand layer (SM vs a ML classification). Much information has been left off this map. None of the TB borings have been include. The information contained in the MW-39 well boring logs were not included suggesting that there is no silt sand layer at the depth suggested on figure 4-4 of between elevation -9 and -10 feet. Boring 112 is of questionable value because it was only drilled one foot into a silt layer. The data for boring 111 indicates that the silty sand layer is encountered at -15.2 feet rather than the indicated -21.0 on figure 4.4. At 122 the log suggests an elevation of -15.4 against -13.0 indicated on figure 4-4. For well 106 the boring log indicates the top of silty sand as -12.1 while the map indicates an elevation of -9.8. Well 121 is -12 on the log and -11.3 on the map. Well 105 is -14.5 on the log and -12.1 on the map. Well 109 is -15.3 on the map and is -14.3 on the log. The log for Well 115A indicates an elevation of -12.4 whereas the log for well 115B indicates the top of the silty sand is at -11.7. These changes have been made on the attached figure 1. The TB boring data has also been included on attached Figure 1. Figure 1 would suggest a far busier surface than does BEI's figure 4-4. When contoured with all the available data, it is not clear that the data actually represents a continuous surface or not. The data from the 39 wells and building 390 borings would suggest that the surface is discontinuous.

Q RFI description

= help me interpret figure 1..

☆

SHALLOW AQUIFER GROUND WATER FLOW

The direction of shallow ground water flow was discussed in detail in reviewing the October 1, 1993 request for a variance to the order to not use W-10 in water level measurements and water quality. There is no need fOR mORE comments except to indicate that the shallow ground water contour maps submitted in the site characterization report did not include W-10. The review of the data done in the October 21, 1993 review of the variance request indicated W-10 was a necessary well in contouring the shallow water level data. Also, in the text (pg. 3-6) the indicated error in reading W-10 is given as 0.04 feet (.5 inches) whereas in the variance request the error in reading W-10 was given as 0.08 feet (1 inch). In either case the error would not be sufficient to have changed any contour map that would have been drawn with the W-10 data. The biggest change in the contour maps only occurs when W-10 data is excluded from the map.

☆ re-do maps?

☆

not tidally caused

The direction of ground water flow in the shallow ground water is highly variable and at time there are reversals in the flow directions. Most important in determining the direction of shwllow ground water flow is the presence of a ground water mound near well 110. This mound suggests there is an area near well 110 where there is preferential recharge occurring. Since most of this area is paved or covered with buildings and the one small area of unpaved surface is too small to account for this mound, it is

☆ acknowledge in RFI - may be I recall.

ask BEI to do what here

recharge source

☆ pump test to show boundary

Or lower perm. so drain slower

Is it a problem for us?

suggested that there has to be a manmade structure causing recharge to the ground water. There could be water mains, sewers, building drains, etc. leaking or discharging directly to the soils under the pavement.

TIDAL TESTING

The data collected from the tidal study of the deeper wells was reviewed and compared to the other data collected from other portions of the investigation. The monitoring tidal cycles allows the calculation of the aquifers conductance. Conductance is the ratio of T/S (transmissivity/storage) determined by the following equation from tidal cycle data in the aquifer and the nearby ocean

vs. hydraulic conductivity?

$$\text{conductance} = T/S = 0.60\ X\ \frac{(To)}{(Ti)}$$

where X is the distance from the waterway, (To) is the period of the tidal cycle (peak to peak, etc.), and (Ti) is the lag time between the peak of the ocean and the peak in the tidal cycle in the obersevation well. The determination of conductance is sensitive to the lag time. As an example, because the time between water level measurements is 30 minutes the lag time for well 108B for any given peak could vary up to +-30 minutes on either side of the real peak. As a result of this uncertenty the conductance can range from 23400 sq. ft./minute to 5850 ft. sq./minute. Since the determination of aquifer conductance is sensitive to the lag time, it is important to determine the relationship between the tidal peaks and the peaks of the well hydrograph as accurately as possible. This ability was compromised further in the BEI tidal study by the location of the ocean tidal monitoring several miles from the site. The conductances that are determined are going to be relative measurements at best. With these reservations, the tidal analysis is believed to be of considerable help in understanding the geologic changes in the lower aquifer and the ground water flow.

describe how logically this is true

No tidal response was observed for wells 106B and 122B even though tidal responses were observed in well 105B located nearly twice as far inland as these two wells. The conductances determined for the various wells are

- 103B---5850 to 2600 ft. Sq./minute,
- 104B---3146 to 2184 ft. Sq./minute,
- 105B---383 ft. Sq./minute, low conductance, high response, more contained? ~~but then~~ storage? ~~should be low~~ but it's not.
- 108B---23400 to 5850 ft. Sq./minute, and
- 115B---4127 to 2866 ft. Sq./minute.

The conductance of 105B is an order of magnitude below the other wells. The lack of response in 106B and 122B can be interpreted in two ways. It is possible that these wells are located in much lower K sediments than the other wells and, therefore, any tidal changes are prevented from reaching these wells. Alternatively the wells

conductivity?

could be located in an area where the storage is much higher than the other wells in the deeper zone. A much higher storage would allow the changes in pressure gradient to be masked by the effects of the higher storage. It is the smaller storage in a confined aqufier that allows the tidal effects to be propagated further inland than in an unconfined aquifer of similar sediments. The boring logs for wells 106B and 122B do not indicate different geologic materials with a lower K than any other well in the deeper aquifer. Well 105, furthest inland, is considered to be in the aquitard sediments but still shows tidal influence. This does not seem to be an explanation the would fit the case.

much contradictory info

Another possible explanation for the lack of response could be related to a much higher storage for this area. The only way to have a larger storage without changing the sediments is to have the aquifer change from confined to unconfined conditions. This would contradict the very high barometeric efficiencies (BE) observed in wells 106B and 122B which indicate smaller storage coefficients than the other wells in the deeper aqufier.

how does BE and confined vs. unconfined inter-relate

why smaller Δ if more tidal response !?

The water level elevations during the tidal study varied by as much as 4 feet at 108B to 0.25 feet at 104B. Well 105B had a change in water level of 0.4 feet. Wells 103B, 106B, and 122B had changes of 1 foot, .5 feet, and .6 feet respectively. The changes in water elevations for all the other wells except 108B and 103B have significant components contributed by barometric changes during the tidal study. Wells 106B and 122B have the highest BE of any wells near 70%. The only way to have this amount of BE is to have a highly confined aquifer with a corresponding lower storage coefficient. The data presented in the characterization report is contradictory.

implications for remediation

SVOC venting CA

DEEP AQUIFER GROUND WATER FLOW

BEI presents a series of horizontal contour maps contouring the heads at various times in the deep aquifer. Figures H-15 to H-27 present a series of snapshots of the heads through the tidal analysis. There is little change in the flow directions over most of the site despite a 4 foot change in elevation in 108B and a 1 foot change in 103B during the test. The ground water flow is generally south/southwest over most of the site turning to south and at times south/southeast toward 108B at the southern end of the site. = ? okay

These flow directions are not significantly different than the time average water levels shown on figure 4-21 nor the snapshots of deep aquifer flow shown on figure 4-8 for March, 1993 and figure 4-9 for July, 1993. The suggestion would be that taking single water level measurements for the deep wells provides an accurate picture of the flow relationships in the deep aquifer. But the comparison of the heads shown on figure 4-8 and 4-9 of the contoured heads does not agree with the heads presented on tables in appendix G. In particular 122B in the tables has an elevation of -5.3 in March, 1993 and is shown on figure 4-8 as -0.54. In July, 1993 the table indicates the water elevation should be -5.17 but figure 4-9 indicates the water elevation is -0.44. No explanation is provided in the report for these discrepancies. When the maps are contoured with the water levels from the tables in appendix G (attached figures 2 and 3) ground water flow in the deep aquifer becomes strongly east to northeast in the area of 122B on both dates.

= change report

still on corrected. now

VERTICAL GROUND WATER FLOW AND HYDRAULIC CONDUCTIVITY TESTING

The K presented in the RFI suggest a ratio of 1266/1/23 between the upper sand aquifer,silty sand aquitard, and lower sand aquifer. These ratios are sufficient so ground water flow in the aquitard will be nearly perpendicular to its upper and lower contacts with the sand aquifers above and below the aquitard. Vertical hydrogeologic cross sections were drawn for April, May, and July, 1993 data (shown on attached figures 4, 5, and 6). The cross section, from south to north, go through wells 108 A and B, 122B, 106 A and B, 115 A and B, 114A, and 105 A and B. The three cross sections have similar patterns of ground water flow. The ground water flow in the upper aquifer is nearly horizontal, the flow in the aquitard is strongly downward, and the flow in the lower sand aquifer is generally horizontal toward 122B. It is not clear if the flow around 122B indicates further vertical flow or if the flow is into or out of the cross sections. The attached horizontal contour maps for the deeper aquifer (figures 2 and 3) suggest flow should be out of the section at 122B.

⊥ or ||?

Is this possible, expected

= need correction or clarification here to report

implication

The hydrogeologic cross sections are consistent with the ratios of K between the observed layering and the K values presented in the report. The cross sections confirm that the silty sand layer acts as an aquitard between the shallow and deeper sand layers. The sections do not aid in understanding the lack of response of 122B and 106B during the tidal monitoring. ~~The cross~~ sections raise some questions about the ground water flow in the area of 122B and 106B. These wells are acting entirely different than the other deep sand wells and there appears to be a channeling of ground water flow to the east. As has been suggested in the past, there is a suggestion that ground water pumping or lowering is occurring somewhere in the vicinity of the site.

→ meaning? + tide support concept of aquitard?

✓ do what to solve

= also where wash away occurred ✓?!

CHEMICAL DISTRIBUTION AND CHANGES WITH TIME

The monitoring wells sampled for rounds 1 and 2 were examined for comparison to the analyzes presented in tables 5-8 to 5-24 for sampling events in April and July, 1993. There has been significant decreases in the number of parameters detected in most wells in addition significant decreases in the concentration of those contaminates detected. At the 103 cluster the A well has previously-? detected 6 different contaminates in the ground water. In the April

between when + when

sampling four of these parameters have lowered to near the detection limits and the others are below the detection limits. In well 104A eighteen contaminates were detected in rounds 1 and 2. In the latest two sampling rounds the number has decreased to 9 detected contaminates. Previously, in well 104B five contaminates were detected; in the April and July sampling all are below the detection limits except phthalates and low levels of TCE. In well 107A seventeen contaminates had previously been detected. In the latest rounds 8 of the contaminates were below the detection limits and the majority of the others were lowered to near the detection limits. Only chloroethane has remained near to previous levels of detections. Similar reductions are recorded for 108A, 108B, 109A, and 110A. known

The newer wells installed since rounds 1 and 2 have found significant contamination in the ground water in the shallow aquifer. The ground water sampling in April and July, 1993 indicate that the highest concentrations of a mixed contaminate plume is at 116, 117, 118, 119, 109, and W-10. Lesser amounts of contaminates are present in 104A, MW-39-3, 107A, and 110. With the exceptions of 104A on the north side and W-10 on the south side, all the other wells correspond to wells that have detected LNAPLs. At these ten wells there are a wide variety of different contaminates apparently representing the mix of chemicals that have been released through time.

A much smaller number of contaminates have reached 111 (methyl chloride and chloroethane), 112 (chloroethane), 113 (vinyl chloride, 1,1,1-TCA, and TCE), 103A (4-methylphenol, chloroethane, TCE), 104A (chloroethane, vinyl chloride), and 108A (fluorene, dibenzofuran, TCE). The levels of most parameters are near the detection limits. Exceptions to this are TCE, benzene, and chloroethane at 103A; TCE at 114A: vinyl chloride, 111-TCA, and TCE at 113A which have significant levels but not the complex mix of contaminates detected at the interior wells.

LNAPL has been detected on the wells shown on the attached figure 7. As was indicated above this LNAPL plume corresponds closely with the wells having the highest concentration of contaminates as well as the most extensive number of contaminates in the shallow ground water.

address after LNAPL? get there at same time as LNAPL!

The wells below the aquitard have had higher amounts and more contaminates detected in the earlier round 1 and round 2 than in the sampling in April and July, 1993. In 103B chloroethane, acetone, and benzene were reported in the earlier two sampling rounds. In the later sampling none of these are reported and only TCE is detected. In 104B acetone, 2-methylnaphthalene, fluorene, and phenanthrene were detected earlier and only TCE is presently detected. While 105B is not a deep aquifer well TCE is detected. In the newer deep monitoring wells acetone and TCE are detected in 122B near the detection limits. It is not clear if these detections

because

?

have any meaning because the ground water flow in this deeper sand layer does not appear to be understood vary well. The head data for 122B would suggest 122B should be down gradient of much of the facility; the lack of response of this well during the tidal study suggests it may be isolated from the majority of the ground water flow under the facility. New well

No DNAPL has been reported in this characterization. The similarity of the LNAPL plume to the highest contamination in the shallow aquifer would suggest that the source for the contamination is the LNAPL and not a DNAPL. The occurrence of a much shallower low K layer at elevation 1 to -1 feet under much of the site complicates the prediction of where DNAPL would be located if present. If a DNAPL had been released or had formed from the contaminates released over a long time, the shallower lower K surface at 1 to -1 feet elevation would control the distribution of the DNAPL until a hole is found to allow further downward migration perhaps to the surface mapped by BEI on figure 4-4 and shown on modified attached figure 1. At present, the data does not suggest a DNAPL present. The coincedence of the LNAPL plume with the major dissolve contaminate plume indicates this is the source of the contaminates in the ground water.

CONCLUSIONS

The data presented in the site characterization report indicates that there is a high concentration multi-component contaminate plume covering about 2.8 acres under the BEI Pier 91 facility. This plume extends off site to the southwest and south of the facility. A more diffused plume made up of fewer contaminates covers about 10 acres and extends several hundred feet offsite to the west, southwest, south, and south east of the facility. An LNAPL plume covering about a 2.5 acres is present under the pipe alley, diesel oil yard, black oil yard, and offsite under the cold storage warehouse. This contamination is predominately isolated to the shallower ground water. The primary source of the contaminates in the ground water appears to be the LNAPL plume. ? which

Contaminates consistent with the contaminates in the shallower aquifer have been detected in the deeper wells in the past. The more recent sampling indicates only TCE is now detected in the lower aquifer. It is not clear that TCE represents the extent of the plume in the lower aquifer or not because of the hydrogeologic conditions encountered during the tidal study indicating three different aquifer conditions present in the deeper wells. The lack of response of 106B and 122B suggests significantly different aquifer conditions than at all the other wells in the deeper ground water. Well 105B is screened in low K sediments as indicated by the boring log and the responses observed during the tidal study. TCE is also detected in 105B. Because of the K contrast between the sand aquifers and the aquitard sediments it is not known what the

= pump test here or not?

?

ground water flow direction in the area of 105B should be relative to the site. The suggested location of 105B would make it upgradient of the facility; however, the expected flow direction in the aquitard sediments should by vertically up or down toward more permeable layers. It is not clear that 105B is actually up gradient of the facility with the present data.

The present knowledge on the LNAPL plume far exceeds that which is necessary to design a LNAPL collection system. There is nothing new nor innovative necessary to establish such a collection system. The same applies to the collection of ground water to remediate the dissolved ground water plume derived from the LNAPL. The pumping of the ground water extraction wells would provide the gradient for the LNAPL to migrate to the skimming pumps.

The data contained in the site characterization report indicates there are several large holes in the monitoring program for the deeper aquifer. There need to be deep monitoring wells between 104B and 103B on the west side. The complexity of the lower aquifer suggest there should be two wells to cover this gap. On the east side there is a large gap between 122B and 108B. There needs to be a deep well between 103B and 108B to cover this gap at the south end of the site. Nothing? is known about the distribution of chemicals in the deep aquifer directly under the facility. There need to be two deep monitoring wells located between 115B in the north and the future location of a deep monitoring well at about W-10 on the south end of the site. After these wells are installed, the tidal study needs to be repeated with the shortcomings of the earlier one corrected. The most glaring shortcomings are the need for shorter intervals of water level measurements and for the ocean tidal responses to be measured at the closest place to the site.

well here even the upgradient?

Not BEI site limited

show me where! why

why

Even though there are some questions about 105B data it is not clear if additional investigation is necessary in this area. The TCE levels are low and the pinching out of the deeper aquifer in this direction suggests that flow in this direction, if it is occurring, would be limited. If at some point additional investigation is warranted, a series of deep wells across the site from 113 to 114 would be necessary. This set of wells should await the results of the additional investigation wells suggested above.

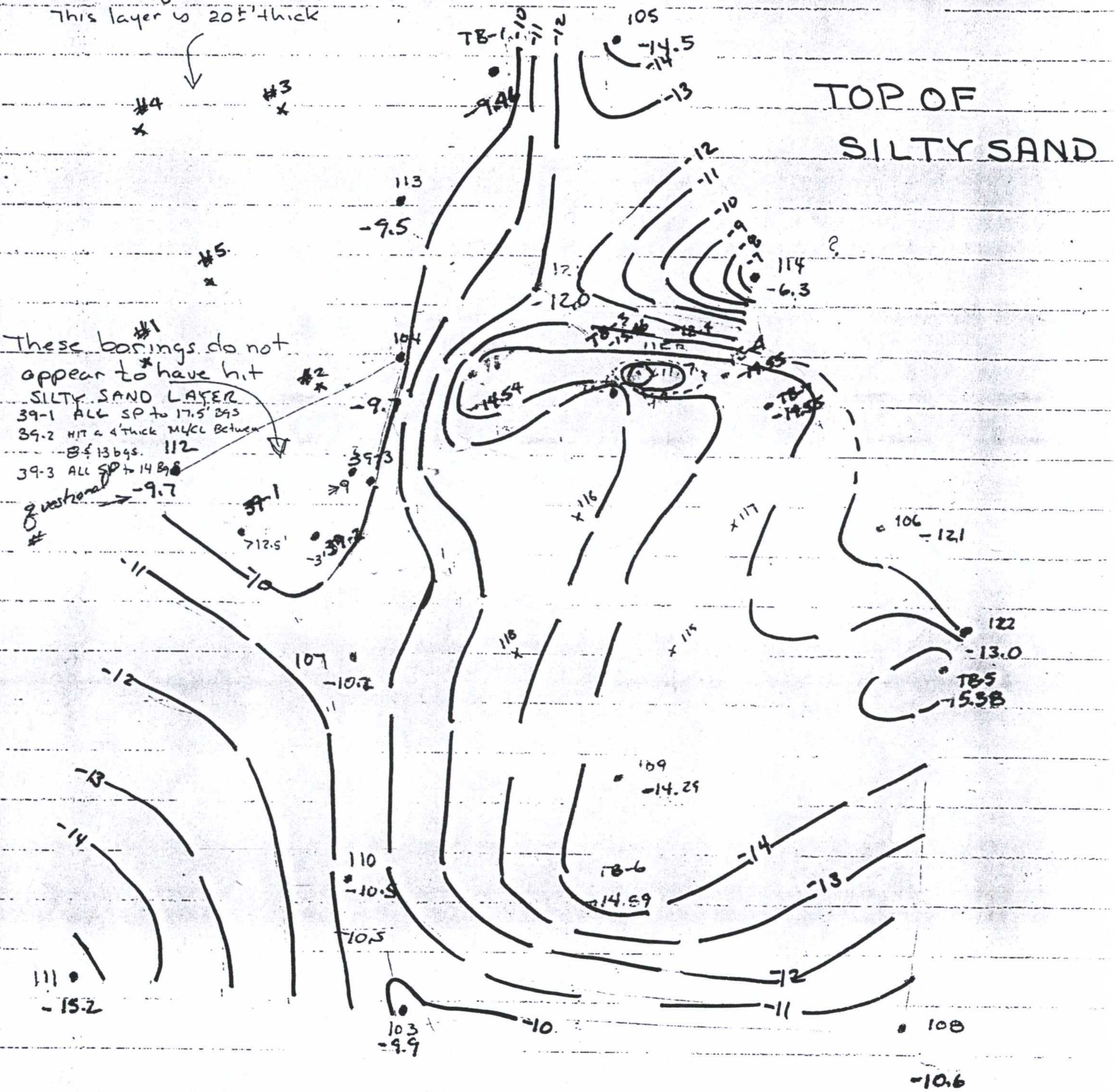
It is recommended that a complete set (One time?) of geochemical parameters be obtained from all the wells on site and offsite in this area. Such information may help identify the sources of the ground water and accentuate the differences in the ground water in each aquifer. The geochemistry may aid in identifying problems that may be encountered in pumping the ground water for long periods of time. Such parameters should include sodium, potassium, calcium, magnesium, iron, manganese, DO, TDS, TOC, bicarbonate, pH, Eh, carbonate, silica, phosphore, chloride, nitrate, nitrite, ammonia, sulfate, sulfide, COD, conductivity, and BOD.

how

how

1987 REPORT (GEOENGINEERS INC)
Borings for City Ice & Cold Storage Company suggest S.S. Layer Starts @ 7'-8' below grd SURFACE (Before building)
& Elevations of -2' to -3' is suggested.
This layer is 20'± thick

VERY SHALLOW SS. ELEVATIONS ARE SUGGESTED BY LOGS for 116, 117, 118, 119
it is possible this SS. Layer extends to 115A



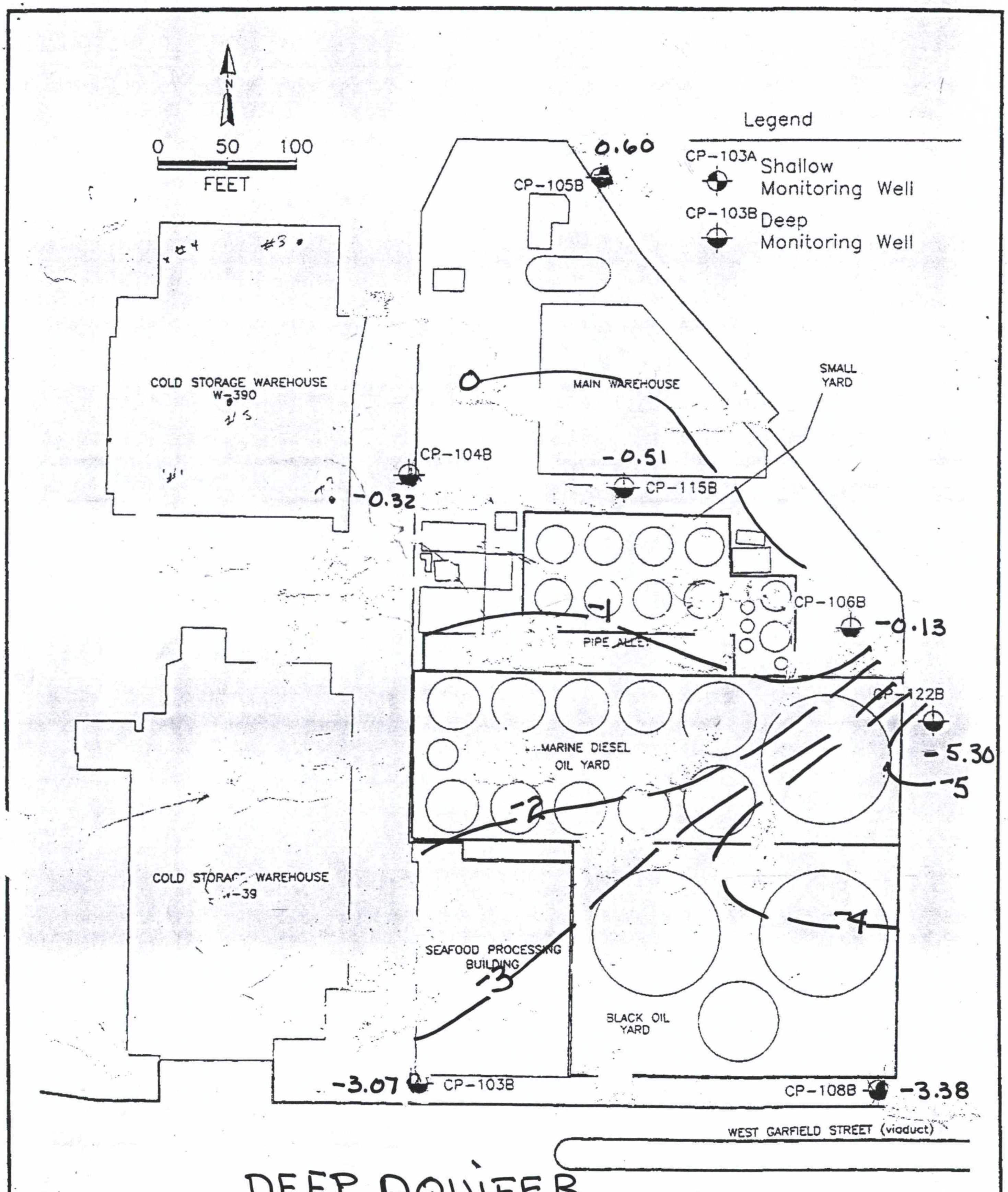
ADDED TB-5
TB6
TB3
TB4
TB2
TB1
114
115A

CHANGED 106B from -9.9 to -12.1
105B from -12.1 to -14.5
111 from -21.0 to -15.2
109 from -15.3 to -14.29

QUESTIONABLE DATA 112 (ONLY 1' S.S. penetrated)

FIGURE 1

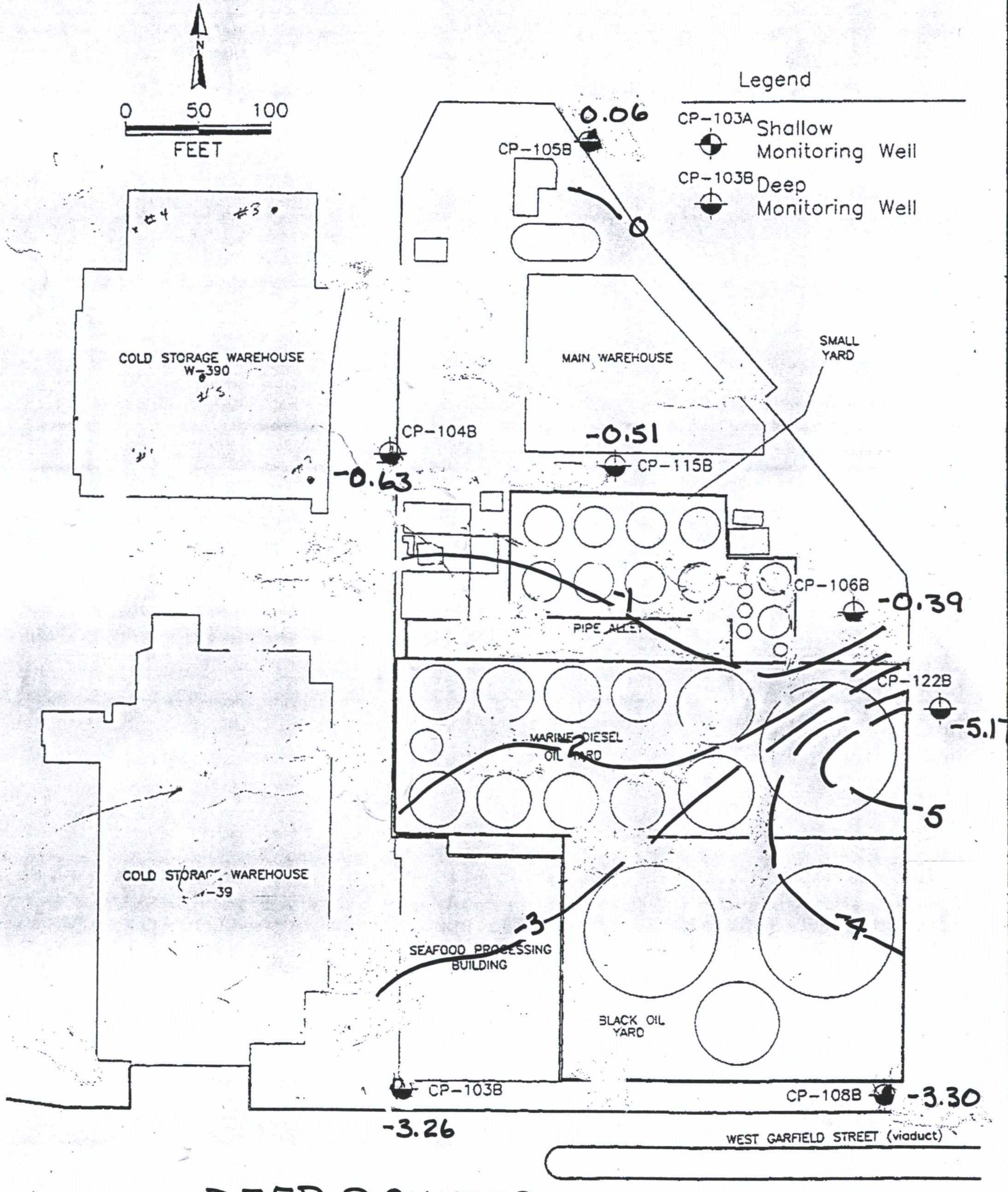
39-1, 39-2, 39-3 DID NOT ENCOUNTER SS. AT DEPTHS BELOW CP112, 104B, 107.



Note: All locations shown are approximate.

DEEP AQUIFER
MARCH, 1993

BU EN	drp	DES.:	PROJECT NO.:
FIGURE 2		APPD:	FIGURE NO.:
		REV.:	

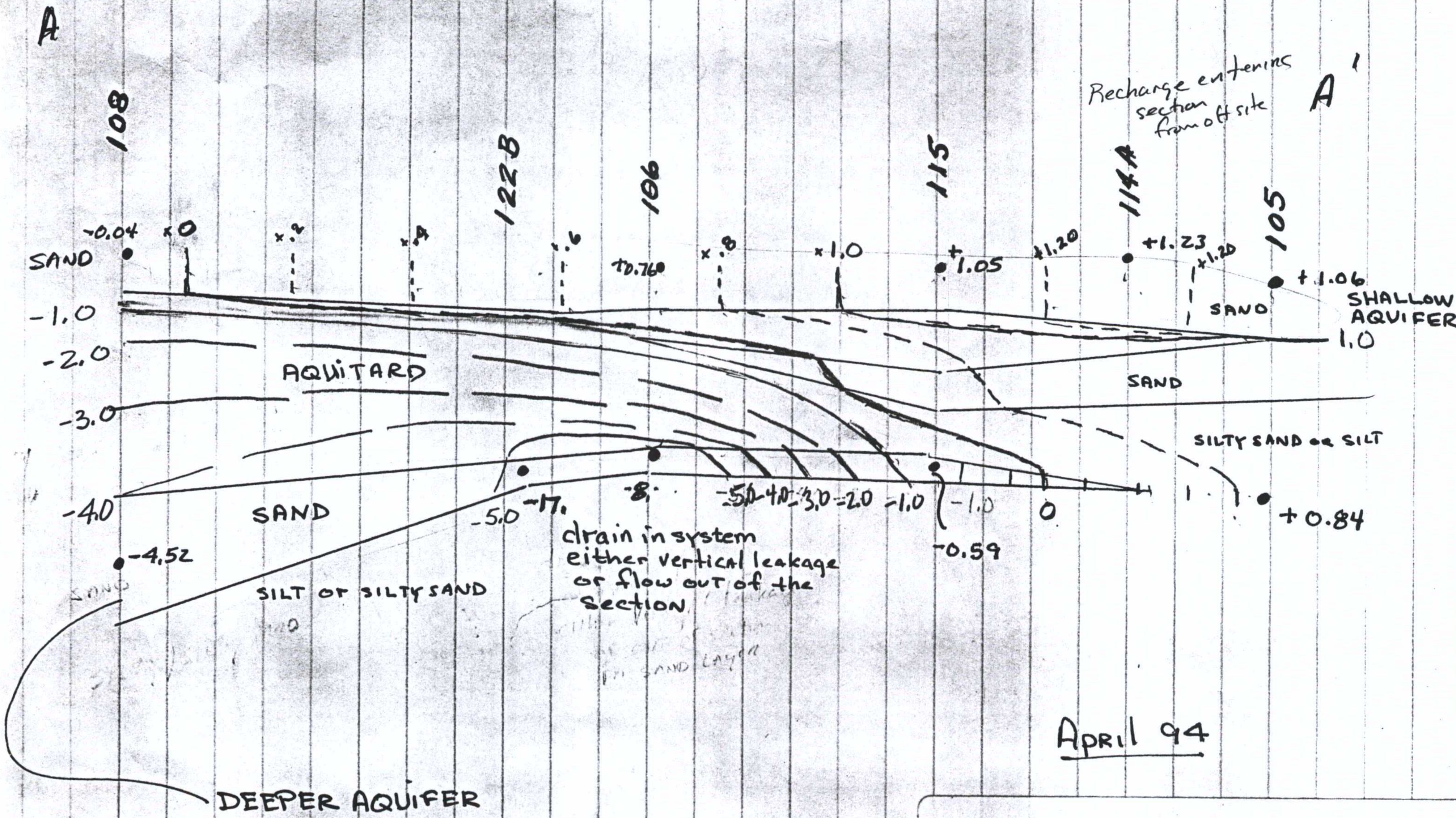


DEEP AQUIFER

Note: All locations shown are approximate.

JULY, 1993

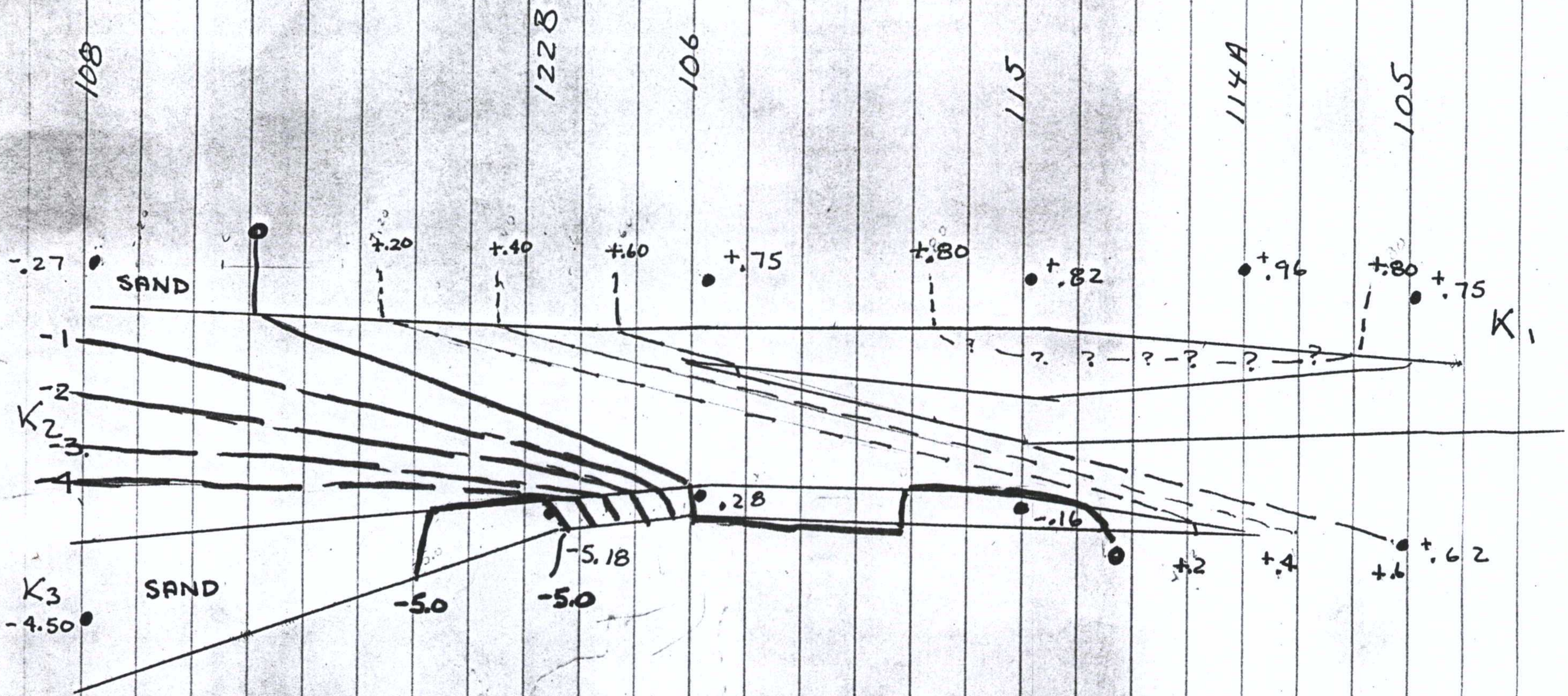
BURLI ENVIR	FIGURE 3	DES.:	PROJECT NO.:
		APPD:	FIGURE NO.:
		REV.:	



NOTE: THERE is A CHANGE IN THE CONTOUR INTERVAL AT THE NORTH END OF SECTION (A')

HYDROGEOLOGIC CROSS SECTION

FIGURE 4

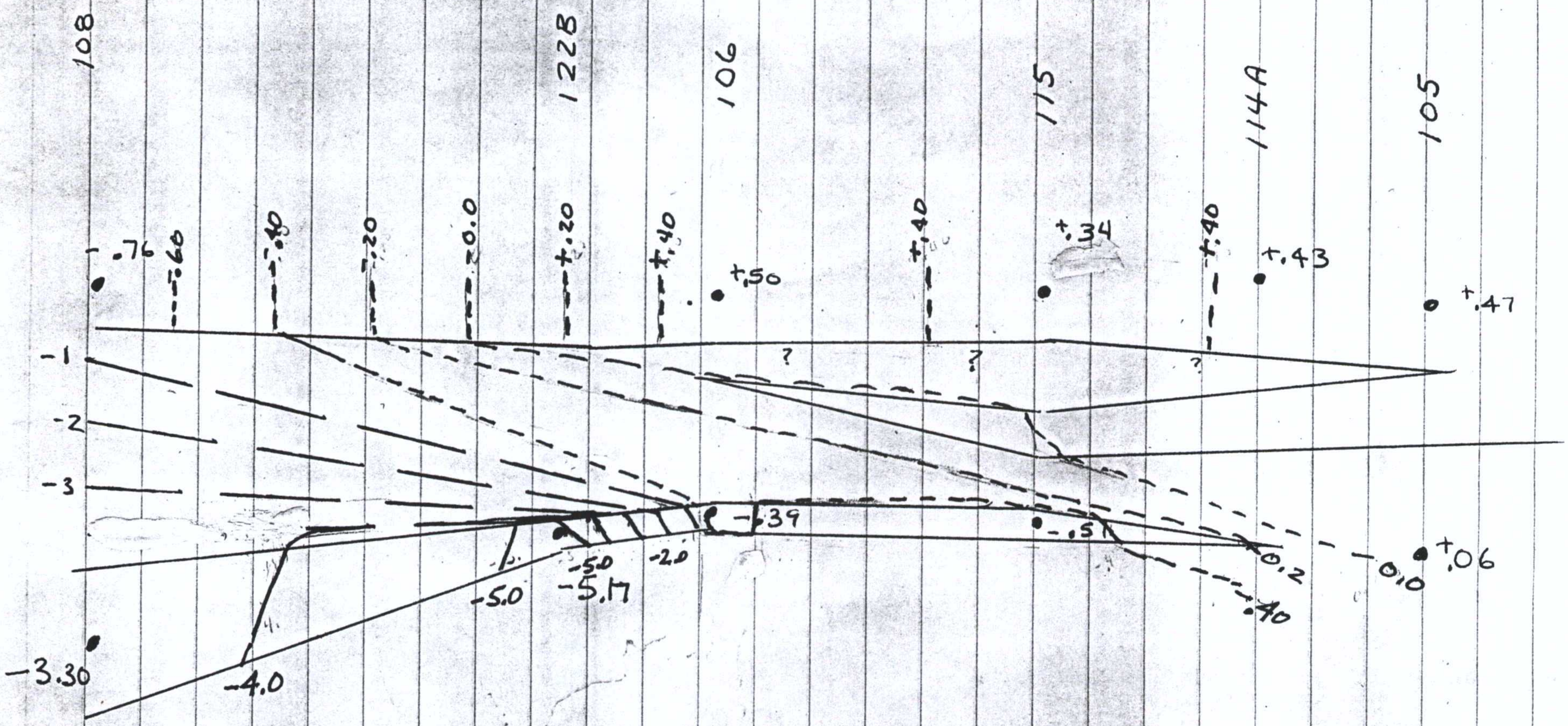


HYDROGEOLOGIC CROSS SECTION

FIGURE 5

RATIO $K_1/K_2/K_3 = 1266/1/23.3$

MAY, 93



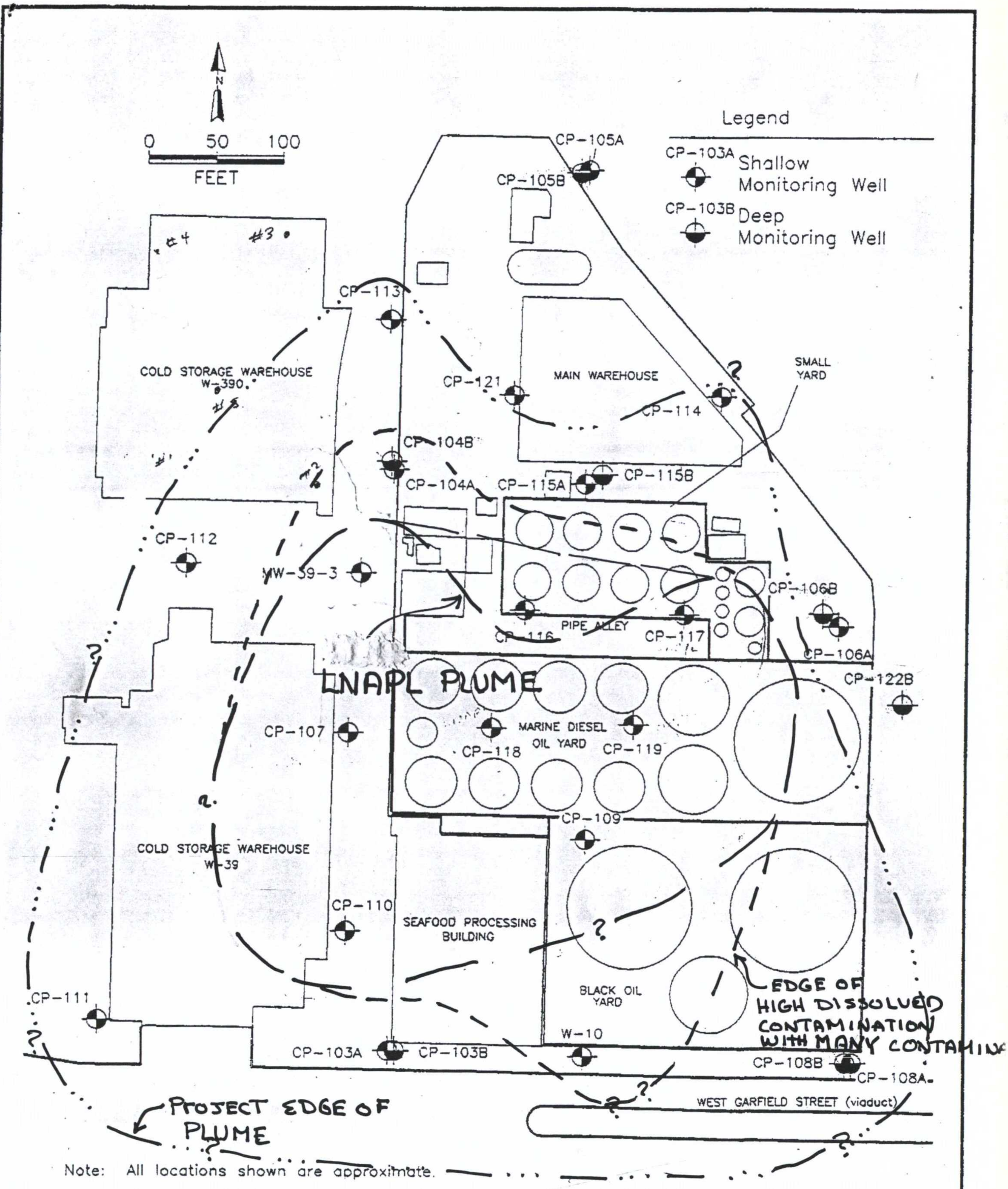
HYD

HYDROGEOLOGIC CROSS SECTION

FIGURE 6

NOTE: THERE IS CHANGE IN THE CONTOUR INTERVAL

JULY, 93



BURLING ENVIRONI	SHALLOW AQUIFER CONTAMINATE DISTRIBUTION FIGURE 7	DES.:
		APPD: JAW
	3	REV.: 3
PROJECT NO.: 624878		